"We not only changed the messaging to students but modified design projects and activities in our Introduction to Engineering courses to include more opportunities for customer engagement and to encourage students to think about and describe the value they are creating for the customers through their designs."

- Amy Trowbridge, Sr Lecturer and Director of the Grand Challenge Scholars Program

**Case at a glance**

**Integration goals:** Modify design projects and activities for Introduction to Engineering courses to include more focus on identifying and pursuing opportunities to create value for customers and society

**Materials affected:** New and revised project documents, lecture slides, lab activities, course assessment rubrics, new EM lecture video

**Lessons learned:** First-year students may initially experience some discomfort when provided with ambiguous problem scenarios, but ultimately will explore opportunities and ideas beyond your expectations. Scaffolding is important to support and direct students’ design efforts.

**Context**

ASU offers more than 55 sections of FSE 100, Introduction to Engineering, and eight sections of its equivalent in the Polytechnic school, EGR 101, Foundations of
Engineering Design I, each year, reaching about 2300 freshmen engineering students. Led by lecturers on the Academic and Student Affairs (ASA) Engineering Education faculty team, the course is project-based and focuses on the core concepts of the engineering design process, teamwork, systems modeling, and systems thinking. Because the introductory course is required, integrating entrepreneurial mindset learning (EML) into it ensures that incoming students are exposed to the 3Cs and EM in the classroom from day one, thereby building on the foundation E2 Camp laid for their longitudinal EM experiences.

Central to Phase I of the initiative, this integration effort began in spring 2016 with a few pilot sections. After piloted materials were revised and all of the course instructors were trained, the revised curriculum was implemented in approximately 23 sections of FSE 100 and seven sections of EGR 101 during fall 2016. Course materials were then further revised, and implemented again in the following semesters throughout nearly all course sections of FSE100 and EGR101.

**Integration details**

The changes we've made to this course have primarily relied upon further emphasizing the central role of the customer in the engineering design process. We've incorporated the language of EM and the 3Cs into course materials, from explicitly stating that the goal of design is to create value for a customer to providing more opportunities for student-led learning and exploration to encourage curiosity. Students are provided more opportunities to learn and apply EM-related skills through activities such as interviewing customers to identify and define specific needs and opportunities within open-ended problem spaces. New materials include a lecture video about EM and how to it relates to the engineering design process.

Integration of EM into FSE100 began in spring 2016 with a few pilot sections of the course, and then expanded to nearly all FSE100 and EGR101 sections in fall 2016. All of the course instructors, nearly 20 lecturers, were trained on EML through a workshop held on campus in summer 2016 to encourage integration of EM into course materials for the fall. More than 14 lecturers and other faculty members modified the course by envisioning, developing, and implementing a variety of new lectures, labs, and EM-focused team design projects to both explicitly address and encourage the 3Cs. All course design projects were revised to explicitly address creating value for the customer and to encourage students to discover customer needs through customer and/or stakeholder interviews and research.

The team developed new projects (for example, Project Spyn autonomous vehicle design) and revised several existing projects (for example, a Renewable Energy project, a self-directed project identifying and addressing pain points and developing value proposition, a Solar Car project, and a Grand Challenges Project) in FSE100 course sections to encourage students' development of the entrepreneurial mindset. In the new and revised FSE 100 design projects, students were provided with ambiguous real-
world problem scenarios and required to conduct research to identify opportunities for creating value and gather information needed to create a successful design solution. Designs were assessed throughout the design process based on measures related to value creation, including customer feedback on proposed ideas and minimum viable prototypes, fulfilling customer needs, and user satisfaction.

Revisions were also made to various lab and lecture activities in the course to incorporate the 3Cs language, and to provide opportunities for students to develop EM-related skills. For example, a ping-pong ball launcher mini-project and assembly line lab series were both revised to incorporate real-world context and a fictional customer to encourage students to focus on creating value. The lecturers also created several new lectures and labs including a water filtration lab and lecture series focused on creating value and utilizing customer feedback during the design process.

In EGR 101, freshmen teams designed a rideable hovercraft according to design requirements posed by high school students who were taking part in a hovercraft competition. Freshmen interviewed high school students and found out user needs and decided on an initial design. The interview process enhanced the curiosity and creativity of possible solutions for both stakeholders. Through additional research and testing, the students identified the important criteria in the hovercraft design. The final product was constrained by a budget that limited the types of materials the teams used for the final working hovercrafts. Upon receiving feedback from the high-school students on the design, the freshmen teams improved their initial designs and submitted engineering drawings of their final designs. On race day, freshmen presented and demonstrated their hovercrafts to the high school students.

The milestones below marked this integration effort’s progress, which began prior to FSE’s formal wide-scale EM integration initiative:

**Fall 2011:** Full-scale implementation of 2-credit, multidisciplinary FSE 100 Introduction to Engineering course (including open-ended, hands-on design projects)

**2011-2016:** Various teaching faculty learned and further incorporated educational best practices such as active learning and open-ended real-world design projects into the course, ultimately excellent preparation for EML

**Spring 2016:** Piloted efforts to further incorporate EML in three sections of FSE 100, and members of the ASU KEEN faculty team qualitatively analyzed student reflections from these FSE 100 pilot courses at the end of the semester. Course efforts and results of the analysis were detailed in a paper, presented at ASEE in June 2017, which won Best Teaching Paper award in the Entrepreneurship and Engineering Innovation division.

**March 2016:** Two lecturers attended Innovating Curriculum with Entrepreneurial Mindset (ICE) workshop to gain insights into incorporating EM into FSE100 and other courses.
June 2016: EM training workshop held for FSE 100/EGR 101 lecturer team.

Summer 2016: Several members of the lecturer team revised old and developed new projects and course materials to incorporate EM; one additional lecturer attended an ICE workshop.

Fall 2016: Implementation of new and revised design projects, lectures, labs, and other course materials in FSE 100 and EGR 101 across most of the 45 sections offered.

January 2017: Faculty co-led a KEEN conference workshop with faculty from another institution on three first- and second-year design projects.

March 2017: One lecturer attended ICE workshop.

June 2017: Faculty papers on integration of EM into FSE 100 presented by lecturer team at ASEE.

July 2017 - Present: Faculty have continued to improve and enhance EM integration into the course. Some faculty have presented at KEEN conferences and ASEE, and KEEN cards related to the efforts have been created and shared on the KEEN online platform.

NOTE: Supporting resources for this case study can be found within its companion KEEN card (link below), which is also where the community can discuss the case and its broader topic.

Integration outcomes

Although rigorous assessment of the entire EM integration initiative is planned, and an assessment instrument has been developed and employed several times, it is difficult to quantitatively evaluate the impact of this integration effort and EM development in students. However, overall, students’ performance and qualitative feedback indicates that they have learned the importance of considering the customer throughout the design process and enjoyed the opportunity to develop creative solutions to opportunities they've identified and chosen within ambiguous problem scenarios. Put another way, students clearly seem to enjoy and gain confidence when they are given the chance to create value for a customer or stakeholder.

Future plans

As of summer 2017, we are more than halfway to where we’d like to be with this integration effort. Our milestones for the immediate future reflect our dedication to further refining how we integrate EML into our foundational courses, even as enrollments increase, and we see potential for additional integration in the future. One outcome of this integration effort is the inclusion of EM into the new Introduction to Engineering Massive Open Online Course (MOOC) offered through ASU’s Global
Freshman Academy. This course was created by lecturers who helped to lead integration of EM into the on-ground courses.

Considerations

As reflected in the milestones described above, the redesign of these courses benefited from their having existing open-ended design projects that already had real-world scenarios. We had material that could be fairly easily adapted when we started, and its existence helped to generate new material. The effort likewise benefited, heavily, from FSE leadership’s support for these courses in general, starting with ensuring that they have a dedicated teaching team (the faculty lecturer group focused on first-year engineering). Various lecturers’ attendance at ICE workshops was another supporting factor which contributed to EM integration efforts.

In addition to faculty, this integration effort depended upon contributions from roles such as administrative staff and teaching assistants. Administrative staff helped coordinate innumerable details and were essential to coordinating training. Graduate and undergraduate teaching assistants have also been important for implementation in the classroom, as they often serve as representatives of customers and other stakeholders. They also helped to alleviate the discomfort some first-year students experienced when provided with ambiguous problem scenarios.

Finally, you may want to keep in mind that students in courses such as these may challenge you in different ways when presented with EML activities and ambiguous problems. Some students will challenge you by finding and wanting to explore opportunities you hadn't intended or thought of previously; as the instructor, you must then provide some guidance to students as a facilitator of their learning and exploration. Again, scaffolding and support are important.

KEEN Card

This case study has a companion card on the KEEN Engineering Unleashed website.

Related Cases

- Curriculum
  Foundations 2: EGR 102

- Engagement
  Rich with Possibilities: Engineering Futures

- Workshops
  Onboarding 1: EM Workshop for Faculty
  Onboarding 3: EM Workshop for Undergraduate Teaching Assistants
Life Cycle
The Impact Meter: Assessing Student Mindset
Institutional Learning: Evaluating the Initiative